FAN ROTOR

Fan units are often manufactured and sold to stockists without the exact performance requirements of the eventual user being known. In such cases it is normal that when sold, the fan manufacturer ensures that as far as possible, the included motor has sufficient capacity so as to cover the fans operation over the entire published fan characteristic.

Generally axial fan units exhibit a "stall" or abrupt change in the slope of their performance characteristic when they reach their maximum attainable pressure value. Operation beyond (i.e. to the left) of this 'stall point' is not recommended because of the unstable nature of the airflow/pressure characteristic, its associated increase in sound level; and its effect on the mechanical integrity of the fan unit. However, the resulting power characteristic to the left of the 'stall point' is generally of declining value with any increase at very low flow (i.e. towards the 'shut off', or zero flow condition) back to the peak value attainable when operating in its stable characteristic.

The attained peak pressure of an axial fan is very much dependent on its tip speed (i.e. proportional to its rotation speed) and to that of the total tip chord or total width of the blades in the tip region.

One kind of fan with a large tip chord is the so called scimitar bladed fan. Another is the sickle bladed fan. The greater chord results in higher pressure generation being achieved at the same tip speed.

As these types are particularly useful for their extra pressure generation capability over conventional axial impellers then it is important that the resulting power characteristic takes on a sensible and acceptable contour. It has been found from test work that very useful pressure developments can

occur on these impellers with wide tip chord when placed within a ducted fan arrangement although hitherto at least scimitar fans have usually been ductless, i.e. they have been made as partition fans or table fans. The inventors have discovered that these large tip chord fans when used in ducted configurations exhibit a rapid increase in power when run under low flow conditions which is well in excess of the "normal" peak power experienced towards the higher flow conditions; such that powers can be as much as 150% of the normal peak power.

According to the invention fan blades extend from a hub provided with a deflector ring at the air delivery end of the rotational axis.

It has been found that by the introduction of the hub 'deflector ring' that this low flow power surge can be controlled with only marginal reduction of the achieved increased performance. This then can result in the normal motor sizing associated with the normal 'peak power' being safely made.

The presence of the hub deflector ring has been found not to seriously effect the throughput of the fan unit from any extra 'blockage effect'. What it does do is stop an increasing flow reversal back through the hub region of the blade, which increases as the main fan throughput is reduced.

The natural centrifugal flow components become more dominant as the main flow reduces this gives a useful increase in pressure attainment to the impeller, be it at the expense of power due to recirculation.

The hub deflector plate in the fan which can be of a flat, inclined or specially profiled section, controls the power to the designers requirement. Thus the hub deflector ring may help a cross-section which broadens,

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preferably increasingly, towards the air delivery end of the rotational axis.

The invention is not solely applicable to axial flow fans. It has been found experimentally to be useful in mixed flow fans. These have generally radially extending impeller blades like an axial fan, but the fan is designed so as to produce a flow characteristic including generally axial intake but with delivery from the fan including a centrifugal or any rate radially directed component. This may result from shaping of the hub and/or of the duct in which the blades rotate, or by using a shroud which is effectively equal to the duct section in which the blades rotate but which is rotatable with the blades. Additionally or alternatively the effect may be caused by the shape and/or location of the blades. In particular, the blades may have axes which lie in planes generally radial of the rotational axis, but which axes are inclined in that plane so as to be contained on the surface of an imaginary cone instead of lying in a plane normal to the axis of rotation.

It has been found that with mixed flow fans occurrences happen similar to the effect described above in relation to scimitar sickle bladed axial fans, especially when the mixed flow fan has a spherical hub and spherical shroud designed to accommodate at least adjustable pitch blades, that is to say ones which are rotatable about their individual axis to any of a range of positions to give different fan characteristic.

It has been found beneficial when designing such impellers for installations requiring either radial or axial airflow discharge that the tip shroud be relatively short in the rearward direction so as to allow the main airflow to radially expand off the protruding blade tips when the installation allows. That is to say, the shroud has an axial length which is less than the developed axial length of the tip chord.

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This flow benefit, when the mixed flow fan is installed in a roof unit, is also apparent when the impeller is run in a ducted configuration. However, in the latter the same increasing power phenomena at reduced flow as experienced in the axial fans is present. This can be overcome by the use of a flat, tapered or contoured hub deflector ring at the rear of the blade root, with little or no effect on the main flow achievement.

The root of each fan blade may extend substantially to the outer edge of the deflector ring. The fan blade may include an extension adjacent to the hub in the air delivery direction. The extension may be triangular.

A typical application of the invention is now more particularly described with reference to the accompanying drawing wherein the sole figure is a sectional elevation view of a mixed flow fan. In the drawing the fan motor may be provided at the location 10 upstream of the fan, that is to say at the inlet end or alternatively at the location 12 which is at the downstream or the delivery end. The arrangement includes a fixed duct 14 providing the inlet and a portion which is substantially a continuation of the fixed duct but is a rotating shroud 16.

The blades are fixed to a hub structure 18 including a part spherical portion 20 and an outwardly flared hub deflector ring portion 22. The one curve may fair smoothly into the other as shown. The shroud 16 may also be part spherical and the centre of curvature of the part spherical area of the shroud and that of the hub 20 may be common.

A plurality of blades 24 are provided fixed at each end to the hub and shroud respectively. The inner and outer ends are shaped to make a close fit with the shroud and with the hub.

In the drawing, the blades are seen to conform closely to the hub including the portions of the blades extending over the hub deflector ring. In the drawing it appears that the blades do not fit closely against the shroud but this is due to the limitation of a two dimensional drawing and to the twist in each blade where the corners 30 and 32 are located at different circumferential positions in relation to the diametric section of the drawing. In practice a close fit is achieved at the shroud.

The blades may be adjustably mounted so that they can be turned about axis A. The portion of the blade end lying against a part spherical surface may have an appropriately shaped end edge which will always lie against a complementary part-spherical surface and hence can be made a close fit. However, in the case of the heel portion of the blade which lies against the hub deflector ring, this is not true, and in this area the blade has to be shaped so that it makes a perfect fit against the ring at an extreme position of twist and a progressively increasing less perfect fit i.e. clearance as the blade setting angle is decreased.

It will be noted that the shroud 16 extends over only a portion of the blade width so that the airflow from inlet to outlet can have a substantial radial direction at the outlet, which is particularly useful in the case of roof units which draw air axially from within the building or ducting and deliver it radially around the perimeter into a roof cowl and thence to atmosphere.

It will be noted that the blades have a somewhat triangular extension 36 fitting against the hub deflector ring and it is particularly important that the area 38 bounded by the broken line 40 joining the corner 30 with a corresponding corner of the extension 36 is not filled in. This shaping permits the driven air to escape from the fan without being caught up in a recirculatory

flow leading to undesirable power absorption which would negate the purpose of the hub deflector ring.